The importance of knowing the lymphatic spread patterns of head and neck cancer for accurate nodal staging on CT: A practical schematic guide

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Learning objectives

Purpose:

Provide a practical guide to improve the knowledge of lymphatic spread patterns of head and neck cancer as a useful tool to interpret lymphadenopathies on computed tomography (CT) images and thus achieve a more accurate nodal staging. We will illustrate this with real cases from our institution, correlating CT images with the results of neck dissection.

Viewers of this educational exhibit will learn:

- The anatomy of lymph node stations according to the TNM system and node groups that are not covered by the standard nodal system.

- Discuss CT imaging criteria used routinely to detect lymphatic macroscopic disease according to size, shape and density.

- The lymphatic drainage patterns of head and neck cancer.

- The peculiarities of thyroid cancer lymphatic dissemination compared to the other head and neck cancers.

- To make a more precise nodal staging of head and neck cancer on CT by adequate knowledge of the previous items.
Background

Anatomy of the lymph node stations in the neck.

-I: Between hyoid bone and mylohyoid muscle; anterior to back of submandibular gland. (fig 2)

IA (submental): Between medial margines of anterior bellies of digastraic muscles.

IB (submandibular): Lateral to level IA nodes; anterior to back of submandibular glands.

-II (upper yugular): Between skull base and lower body of hyoid bone; posterior to back of submandibular gland; anterior to back of sternocleidomastoid muscle. (fig 3)

IIA: Anterior, lateral, medial, or posterior to internal jugular vein. Inseparable from the vein (if posterior to vein).

IIB: Posterior to internal jugular vein; separable from vein -Level III (middle yugular ): Between lower body of hyoid bone and lower cricoid arch; anterior to back of sternocleidomastoid muscle.

Level III (middle yugular ): Between lower body of hyoid bone and lower cricoid arch; anterior to back of sternocleidomastoid muscle (fig4)

-IV (lower yugular): Between lower cricoid arch and clavicle; anterior to a line connecting back of sternocleidomastoid muscle and posterolateral margin of anterior scalene muscle; lateral to carotid arteries. (fig5)

Level V (posterior triangle): Between skull base and clavicle; posterior to back of sternocleidomastoid muscle; posterior to line connecting back of sternocleidomastoid muscle and posterolateral margin of anterior scalene muscle; anterior to anterior edge of trapezius muscle (fig6).

VA: Between skull base and lower cricoid arch.

VB: Between lower cricoid arch and clavicle.

-Level VI ( anterior compartment/upper visceral nodes): Includes pre and paratracheal nodes, precricoid (Delphian node) and the perithyroidal nodes along the recurrent laryngeal nerves. The superior boundary is the hyoid bone, the inferior boundary is the supraesternal notch. The lateral boundary are the common carotid arteries (fig 7).
Anatomy of the lymph node in the neck.

The retropharyngeal nodes are divided into the medial and lateral groups. The medial group is located in the suprahoid retropharyngeal space near the midline, and rarely found in normal subjects. The lateral group is known as the nodes of Rouviere, and is located between the carotid artery and longus colli muscles. A retropharyngeal lymph node more than 6 mm in diameter may be considered abnormal in cancer patients.

Established imaging parameters for abnormal lymph nodes:

The assessment of normal versus abnormal lymph nodes is made based on established parameters such as: the size, contour, homogeneity and necrosis.

Size and contour: Loss of normal ovoid shape, adopting a rounded shape. Short axis > 1.5 cm in II segment and >1 cm in the rest of locations is considered abnormal.

Size

- Level I: 10mm
- Level II: 15mm
- Level III: 10mm
- Level IV: 10mm
- Level V: 10mm
- Retropharyngeal: 7-10mm

It is not appropriate to perform a nodal value based on the size, because although the malignant nodes are often enlarged, may also be, inflammatory lymph, and there may be metastatic deposits in normal-sized nodes.

Features of the lymph nodes in imaging studies:

Control serial studies, increasing size of a previously existing node, regardless of the measure of its Homogeneity: Lymph node invasion by tumor cells produce heterogeneous enhancement zones with low density areas which
should be considered pathological. Diameter should be considered suspicious for malignancy.

Necrosis: The existence of central necrosis can diagnose a lymph node as pathological, until proven otherwise, regardless of size. When the degree of necrosis is very important, nodules can present cystic appearance, with a very thin wall. A head and neck cancer should be ruled out in an adult with a single cystic lesion of this nature.

Uncertain radiological signs of malignancy:

Shape
Number
Localization

Certain radiological signs of malignancy:

Internal architecture: central necrosis is specific of malignancy, but it is a late finding.

Margins.

Nodal calcifications:

Ultrasound is the most sensitive technique for the detection of calcifications. These are not very specific and can be found in benign and malignant processes.

Lymph node hilium:

90% of the normal node with short axis greater than 5 mm, has an identifiable sonographically echogenic hilium. The absence of this hiliar echogenicity qualifies a lymph node as pathological. The lower spatial resolution of CT and MRI, decreases the sensitivity to detect this hilium so its absence is not a fact commonly used in these techniques.
<table>
<thead>
<tr>
<th>Imaging classification</th>
<th>Definition</th>
<th>Drainage pattern</th>
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<tbody>
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<td>Level IA</td>
<td>Between medial margins of anterior bellies of digastric muscles.</td>
<td>Mandible, cheek, lip, anterior gingiva, floor of the mouth, tip of the tongue</td>
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<td>Level IB</td>
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<td>Lateral mandible, lip, cheek, nose, palate, anterior tongue, floor of the mouth submandibular and sublingual glands.</td>
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<td>Between skull base and lower body of hyoid bone; posterior to back of submandibular gland; anterior to back of sternocleidomastoid muscle</td>
<td>Pharynx, tonsils, face, parotid gland, retropharyngeal nodes, submental nodes, submandibular nodes</td>
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## Neck levels anatomy and drainage pattern (part II)

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<td>Nasopharynx, oropharynx, oral cavity, hypopharynx, larynx, submental nodes, submandibular nodes</td>
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<td>Level IV</td>
<td>Between lower cricoid arch and clavicle; anterior to a line connecting back of sternocleidomastoid muscle and posterolateral margin of anterior scalene muscle; lateral to carotid arteries.</td>
<td>Hypopharynx, thyroid, subglottic larynx, esophagus, superior and middle jugular nodes.</td>
</tr>
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<td>Between skull base and clavicle; posterior to back of sternocleidomastoid muscle; posterior to line connecting back of sternocleidomastoid and posterolateral margin of anterior scalene muscle; anterior to anterior edge of trapezius muscle</td>
<td>Skin (occipital, mastoid), scalp, lateral neck.</td>
</tr>
<tr>
<td>Level VA</td>
<td>Between skull base and lower cricoid arch</td>
<td></td>
</tr>
<tr>
<td>Level VB</td>
<td>Between lower cricoid arch and clavicle</td>
<td></td>
</tr>
<tr>
<td>Level VI</td>
<td>Between lower body of hyoid bone and top of manubrium; between carotid arteries.</td>
<td>Larynx, pyriform sinus, thyroid gland, trachea, esophagus</td>
</tr>
<tr>
<td>Level VII</td>
<td>Below top of manubrium; between carotid arteries; caudal to innominate vein.</td>
<td>Upper chest.</td>
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**Table 5:** Table 1.2

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**Table 2:** Table 2

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Fig. 1: Neck levels

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Fig. 2: Level I

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Fig. 3: Level II

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**Fig. 4:** Level III

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**Fig. 5:** Level IV

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Fig. 6: Level V

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Fig. 7: Level VI

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**Table 3:** Tabla 3

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Findings and procedure details

Limitations of CT in lymph node evaluation

The most significant procedure for detection of lymph node metastases is currently B mode sonography, completed by Doppler sonography in combination with sonographically guided aspiration cytology. It disposes of a sensitivity of 80% and a specificity of 98%, superior to computed tomography (CT) and to magnetic resonance imaging (MRI).

Further, sonography allows detailed examination of the intranodal architecture while the diagnosis of the lymph node metastases by means of computed tomography is mainly based on measures of the nodal size.

There is the problem of micrometastases and the fact that a high number of cervical metastases have a size of less than one centimeter.

CT is the first imaging study to search for a primary tumor in a patient with lymphadenopathies in most institutions, so the knowledge of the lymphatic drainage of head and neck tumors can help to compensate these limitations. (table 3)

Direction and extent of lymphogenic metastasis.

-Lips and oral cavity.

Upper lip cancer may affect level I, buccal and parotid lymph nodes.

Cancers of the lower lip (about 95% of the lips cancers) has a relatively low metastatic tendency. Anterior oral cavity mainly drains to the level I lymph nodes, while the posterior part may also drain to level II lymph nodes. In some cases the lingual lymph nodes may be involved (superior to the mylohyoid muscle).

Tongue cancer (25-40%) may affect exclusively level IV lymph nodes. (skip metastasis).

(Fig 8).

-Nasopharynx

Nasopharyngeal cancers show a high metastatic rate. Retropharyngeal lymph nodes (RP) are the first station of metastatic nasopharyngeal cancers (94%).
The lymphatic drainage of the nasopharynx is into the retropharyngeal lymph nodes and lymph nodes of level II.

(Fig 9).

-Larynx

Supraglottic and glottic areas drain to II and III lymph nodes and subglottic area to level III and IV lymph nodes. Involvement of levels I and V is unusual in laryngeal cancers.

Prelaryngeal (delphian) lymph node involvement (afflux from the area of the petiulus, the anterior commissure and the subglottis) is associated with a poor prognosis and a high rate of locoregional recurrences.

(Fig 10).

-Oropharynx

Oropharyngeal region drains into levels II, III, and retropharyngeal (RP) lymph nodes.

Epidermoid carcinomas affecting the posterior or lateral oropharyngeal wall preferably metastasize into the retropharyngeal and II level lymph nodes.

The retropharyngeal lymph node metastases determine significantly the locoregional recurrence rate and may influence negatively the prognosis of the patients.

(Fig 11).

-Skin

The parotid gland is the first station of lymphatic dissemination in squamous cell carcinomas of the skin (parotid gland: dark green).

Their close lymphogenous contact cervical lymph nodes (level I, II, III, and VA depending on the site of the primary cancer) (light green) are involved in more than 50% of the cases.

(Fig 12).

-Hypopharynx

The hypopharynx area drains to the lymph nodes of the levels II, III, and more rarely IV.

The first station of the posterior hypopharyngeal wall lymphatic drainage is the retropharyngeal lymph nodes, whose lymph fluid is forwarded via collectors to the levels II
and III. An affection of the lymph nodes of level I or level V occurs rarely in hypopharyngeal cancer.

There is no direct relationship between the tumor size and the incidence of lymph node metastases in cancers of the hypopharynx.

(Fig 13).

- Thyroid

Lymphatic lymphadenopathies of thyroid cancer differs from the other head and neck tumors in that:

They are usually small in size (the size criteria is not useful here).

Surgeons follow a different classification to do neck dissection: central compartment (VI: pretracheal, paratracheal), lateral compartment (in this order: IV, III, II) and superior mediastinal nodes (VII)

Microcalcifications in the lymph nodes is another sign of nodal involvement

There is a cross lymphatic drainage in the thyroid gland. This is why we can find contralateral lymphadenopathies at the time of presentation.

It is important to know that lymphatic recurrence can be found especially in the central compartment, IV space, and retropharyngeal space (Fig 14).
A prelaryngeal (delphian) (arrow) and a pretracheal adenopathy (arrow) were detected. The presence of these adenopathies that do not belong to the expected lymphatic drainage of this type of tumor, and the asymmetry in the thyroid lobules (arrowheads) and this patient with a previous thyroidectomy, raised the suspicion of thyroid cancer recurrence.

81 year old male with tongue cancer treated with surgery and radiotherapy, and previous thyroidectomy of unknown cause. Tumor local recurrence consisting of a tumor mass involving the left posterior third of the tongue and sublingual space (arrowhead) with midline involvement and extension to the ipsilateral oropharynx. Left IIA necrotic adenopathies were seen (arrow) in sagital and axial planes.

Fig. 8: Lips and oral cavity

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Fig. 9: Nasopharynx

40 year-old patient with a palpable lateral neck mass. CT shows nasopharyngeal asymmetry with blurring of normal structures on the right side (arrowhead). Necrotic lymph nodes were seen in left retropharyngeal space (arrowhead), right IIA (arrow) and left IIb (arrow) stations. A right T1 nasopharyngeal cancer was confirmed at surgery.
A 60 year-old male presented with dysphonic voice for months. Contrast-enhanced CT shows an enhancing supraglottic lesion that caudally extends to the left paralaryngeal fatty space and anterior comissure (arrow). Notice a left IIA metastatic necrotic lymph node mass, which loses fat separation plane with the sternocleidomastoid muscle (extracapsular spread) and compresses the jugular vein (arrowhead). A supraglottic T2 N2b cancer was confirmed after surgery.

**Fig. 10:** Larynx

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60 year-old male who presents at the emergency ward with a lateral neck mass.

Contrast-enhanced CT shows extensive pharyngeal cancer infiltrating the left lateral wall of the oropharynx, tonsillar region and vallecula of the left side (arrow). Notice the necrotic lymphadenopathy conglomerate in IIA and III regions (arrowhead) with extracapsular spread, as well as a left necrotic retropharyngeal node (arrow). T2N3M0 pharyngeal carcinoma. The patient was treated with chemo and radiotherapy.

Fig. 11: Oropharynx

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87 year-old male who presents with a right cheek mass, infiltrating the inferior eyelid. Contrast-enhanced CT shows the right facial mass (arrow) with a right parotid adenopathy and a submental (IA) adenopathy (arrow), both with necrosis. Squamous cell carcinoma in the right cheek was confirmed at surgery, as well as 3 metastatic right parotid lymph nodes out of 5.

**Fig. 12: Skin**

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54 year-old male with left piriform sinus mass (arrow). Ipsilateral IIA lymphadenopathy (arrow) A total laryngectomy and bilateral neck dissection was performed. One lymphadenopathy for each side of the internal jugular chain was found to be infiltrated by tumor. The right one has a normal appearance on CT (not shown).

Fig. 14: Hypopharynx

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63-year-old male who presented with dysphonic voice for right vocal cord paralysis. Contrast-enhanced CT shows a lower right thyroid lobule mass (arrow), and pathologic nodes in levels III (arrow), IIIB (arrow), IV (arrow), pretracheal VI (arrow) and right paratracheal VI (arrow).

The patient underwent total thyroidectomy, right central compartment dissection, and right lateral compartment dissection, and I-131. Thyroid papilar carcinoma T4a N1b (Iva stage)

**Fig. 13: Thyroid**

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### Table 4: Table 4

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Conclusion

Contrast-enhanced computed tomography is the first technique to confirm diagnosis of head and neck squamous cell carcinoma and to do the TNM staging in most institutions.

This presentation reviews the anatomy and classification of cervical lymph nodes, diagnostic criteria and imaging findings of lymph node metastasis on CT.

Our main purpose is to highlight the importance of knowing the lymphatic drainage pathways of head and neck squamous cell carcinomas as a useful tool to improve nodal staging by imaging, and also to detect the primary tumor of abnormal lymphadenopathies depending on its location.
References


